



PROTECTING BIRDS in Agricultural Landscapes





Yellow Warbler
Credit: Helen Atthowe

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Pesticide Danger to Birds: A RISK EVALUATION CHART

INTRODUCTION

Farmers benefit from the pest control services of raptors and insectivorous birds. When pesticides are treated as a last resort rather than as a first line of defense, overuse is avoided. Excessive pesticide use not only kills pests but also reduces the food base for birds. Without this food source, birds and other beneficial organisms are absent when pest populations surge. Moreover, pesticides can poison these natural allies, which are essential for maintaining ecological balance.

If pesticides are needed, whether organic or conventional, those used with a low rating for bird acute or chronic toxicity in this chart will result in the most safety for birds on the farm. Pesticides that also have low ratings for the widescale effects to soil, water, other wildlife and humans should also be considered. If pesticides with higher ratings are currently being used, they can be swapped for those with lower ratings.

Preventative practices, like ensuring crops grow in fertile, biodiverse soil, make the plants less attractive to pests and help to eliminate pesticide applications. Other habitat practices like keeping the soil covered with mulch and cover crops aid beneficial ground dwelling insects in attacking pests. Planting hedge-rows and patch habitats support above-ground bird and insect predators and parasitoids, reducing pests which also helps decrease the need for pesticides.

This handout explains bird pesticide toxicity and other pesticide impacts, and offers practical measures to help prevent poisoning. A lack of information, limited access to it, and failure to recognize the problem are often the primary causes of pesticide effects, rather than intentional harm. Most pest control programs can be adjusted to minimize or eliminate harming birds without significant expense or inconvenience to the grower.



DEFINITIONS OF COLUMN HEADERS

PRODUCTION TYPES:

Organic Production: Materials approved by the National Organic Program. They can be used in conventional production, but not the reverse.

Conventional Production: Materials used in non-organic agriculture.

ACTIVE INGREDIENT / PRODUCT: The substance in the pesticide that kills, controls or repels pests.

References: 1, 2, 26

TRADE NAME EXAMPLES: The brands of the pesticide products that contain active and other 'inert' ingredients in a variety of formulations such granules, powders, emulsifiable concentrates and liquids. Reference: 3

TYPES: Specific pesticides used for killing/controlling specific pests. References: 1, 2, 3, 4, 5

(Al) Algicide

(An) Antimicrobial

(F) Fungicides

(Fm) Fumigant

(H) Herbicides

(I) Insecticides

(Mi) Miticides

(Mo) Molluscicide

(N) Nematicides

(Re) Repellent

(Ro) Rodenticides

first-generation
anticoagulant (**FGAR**),
second-generation
anticoagulant (**SGAR**) or
non-anticoagulant (**non-a**)

**(V) Vertebrate
Control**

We included the most widely applied pesticide active ingredients in California, based on acreage and total pounds used, per CA Department of Pesticide Regulation data (2021–2022). To this list, we added six problematic rodenticides and three vertebrate control pesticides identified by Raptors Are the Solution. We also included two insecticides identified by American Bird Conservancy. Additionally, we included 21 common organic pesticides, mostly from the Xerces Society's Organic Pesticides publication.

BIRD RISK: Short- or long-term bird toxicity can occur. References: 1, 2, 6

Acute Toxicity: Ability of a substance to cause adverse effects within a short period after dosing or exposure. The thresholds below are in mg kg⁻¹ d.

 = Low = > 2000

 = Moderate = 100 - 2000

 = High = < 100

Chronic Toxicity: Capacity of a chemical to cause harm following chronic exposure or to produce effects that are persistent (mg kg⁻¹ d):

 = Low = > 200

 = Moderate = 10 - 200

 = High = < 10

WIDE-SCALE EFFECTS: Risks to soil, water, wildlife and humans are rated. References: 1, 2, 6

Environmental fate: Assesses how a chemical moves, where it goes, how long it persists, and how it transforms in air, water, soil.

Ecotoxicity: Measures the adverse effects on mammals, birds, fish, water fleas, bees, and earthworms.

Human health: Evaluates a range of toxicity data, exposure limits, and hazard indicators regarding effects on people.

NOTE: Most bird data is from references 1, 2 and 26, with additional information drawn from references 7 through 25.



IMPACTS OF COMMON PESTICIDES ON BIRDS AND THE ENVIRONMENT

ACTIVE INGREDIENT / PRODUCT & TRADE NAMES EXAMPLES	TYPE	BIRD RISK		WIDE-SCALE EFFECTS			NOTES
		Acute Toxicity	Chronic Toxicity	Environ. Fate	Eco-toxicity	Human Health	
ORGANIC PRODUCTION							
Acetic acid (vinegar) <i>Green Gobbler, Blendmagic Weed and Grass Killer</i>	H			High	Moderate	Low	It has a low to medium oral toxicity to most biodiversity. It's highly corrosive, so may damage anything it comes in contact with. ¹
Azadirachtin A <i>Azadirect, Ecozin</i>	I	Moderate		Moderate	High	Moderate	It has high chronic toxicity to fish. ²
Bacillus amyloliquefaciens ssp. plantarum <i>Double Nickel</i>	An F			High	Moderate	Moderate	
Bacillus thuringiensis <i>XenTari, Dipel</i>	I	Moderate		Moderate	Moderate	Moderate	
Bacillus subtilis <i>Serenade, Cease</i>	F	Moderate		High		Moderate	
Beauveria bassiana <i>Botanigard</i>	I				Moderate	Moderate	
Borax	F H I	Moderate			Moderate	High	
Boric acid (Disodium octaborate tetrahydrate) <i>Boracare, Borathor, Termite Prufe</i>	F H I	Moderate			Moderate	High	It is highly soluble in water. It tends to have a low to moderate toxicity to biodiversity. Boric acid has a low oral mammalian toxicity and is a recognised irritant. ¹
Capric acid <i>Suppress, Fireworxx</i>	H					Moderate	Capric acid and Caprylic acid are often blended together into one product, hence the trade names listed for these two herbicides are the same.
Caprylic acid <i>Suppress, Fireworxx</i>	H			Moderate	Moderate	Moderate	Ditto
Cinnamaldehyde <i>Cinnerate, Vertigo</i>	F I	Moderate		Moderate	Moderate	High	
Citric acid	F I			High	Moderate	Moderate	
Copper hydroxide <i>Champ WG, Kocide 3000, CuPRO 5000 DF</i>	B F	Moderate		Moderate	High	High	It is moderately toxic to mammals and most biodiversity. ¹ Potential Groundwater Contaminant (PGC) pollution. ³

PESTICIDE TYPE: (Al) Algicide (F) Fungicide (H) Herbicide (Mi) Miticide (N) Nematicide (Ro) Rodenticide (An) Antimicrobial (Fm) Fumigant (I) Insecticide (Mo) Molluscicide (Re) Repellant (V) Vertebrate Control

TOXICITY / RISK LEVEL: ■ Low ■ Moderate ■ High ■ No Data

ACTIVE INGREDIENT / PRODUCT & TRADE NAMES EXAMPLES	TYPE	BIRD RISK		WIDE-SCALE EFFECTS			NOTES
		Acute Toxicity	Chronic Toxicity	Environ. Fate	Eco-toxicity	Human Health	
ORGANIC PRODUCTION							
Copper oxide <i>Nordox 75 WG</i>	F I	Yellow	Grey	Green	Yellow	Yellow	It is moderately toxic to mammals and most biodiversity. ¹ PGC pollution. ³
Copper oxychloride <i>Cupravit</i>	F	Yellow	Grey	Yellow	Red	Yellow	It is moderately toxic to mammals and most biodiversity. ¹
Copper sulphate <i>Monsieur Bordeaux</i>	Al B F	Red	Grey	Green	Red	Yellow	It is moderately toxic to mammals and most biodiversity. ¹
Corn gluten <i>Safer Play, Gluten-8</i>	H	Grey	Grey	Grey	Grey	Green	
Cottonseed oil	F I	Grey	Grey	Grey	Grey	Green	
Cryolite <i>Kryocide, Prokil</i>	I	Green	Grey	Red	Yellow	Yellow	Risk of acute toxicity of bobwhite quail was practically nonexistent. Not expected to be acute for mammals, aquatic organisms or beneficial insects. ⁷
Cydia pomonella granulosis virus <i>CYD-X HP, Madex</i>	I	Green	Grey	Grey	Green	Green	Granuloviruses only infect moths in the Tortricidae family. ⁸
Diatomaceous earth (Kieselgur) <i>Cab-O-Sil, Aerodisp, SilicoSec</i>	I	Green	Grey	Red	Green	Yellow	
Glucoladium catenulatum <i>Prestop</i>	F	Grey	Grey	Grey	Yellow	Green	
Hydrogen peroxide (hydrogen dioxide) <i>Generic H2O2 products</i>	B F	Green	Grey	Grey	Red	Yellow	At higher concentrations it is toxic to aquatic systems. ¹
Insecticidal soap (Fatty acids) <i>Safer soap</i>	I	Green	Grey	Yellow	Yellow	Green	May irritate skin and eyes. Risks to biodiversity are considered low to moderate. ²
Kaolin <i>Surround Crop Protectant</i>	I Re	Green	Grey	Grey	Green	Red	
Lime-sulfur	B F	Grey	Grey	Red	Yellow	Red	
Mineral oil (Paraffin oil) <i>Banol 50</i>	F	Green	Grey	Yellow	Red	Red	
Paecilomyces fumosoroseus (Isaria fumerosa Apopka)	I	Green	Grey	Grey	Yellow	Green	It is non-hazardous and non-pathogenic towards amphibians, birds, and mammals. ⁹

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ACTIVE INGREDIENT / PRODUCT & TRADE NAMES EXAMPLES	TYPE	BIRD RISK		WIDE-SCALE EFFECTS			NOTES
		Acute Toxicity	Chronic Toxicity	Environ. Fate	Eco-toxicity	Human Health	
ORGANIC PRODUCTION							
Peroxyacetic acid <i>Jet-Ag, OxiDate 5.0</i>	B F			High	Moderate	Low	
Phosphoric acid (Disodium phosphonate) <i>Mildicut</i>	F	Moderate		High	Moderate	Low	
Potassium bicarbonate <i>Eco-mate, Milstop</i>	F	Moderate		High	Moderate	Low	
Potassium phosphite (Potassium hydrogen phosphonate) <i>Stamina</i>	F	Low	Moderate	High	Moderate	Low	
Pyrethrin (pyrethrin I) <i>Pyganic</i>	I	Moderate		Moderate	High	Low	Slightly or moderately toxic to birds, and extremely toxic to fish. It is unlikely to concentrate in the food chain. ¹⁰
Reynoutria sachalinensis extract <i>Regalia</i>	F	Low			Moderate	Low	
Sabadilla	I	High		Low	High	Moderate	
Sodium bicarbonate	F	Low		Low	Low	Moderate	
Sodium carbonate peroxyhydrate <i>Technical Sodium Carbonate Peroxyhydrate, TerraCyte</i>	AI F	Low					At label rates, no harm is expected to birds, other terrestrial animals, freshwater fish or freshwater invertebrates. ¹¹
Spinosad <i>Entrust</i>	I	Low	Moderate	Moderate	High	Moderate	
Streptomyces ssp.	F	Low			Moderate	Low	
Sulfur <i>Kumulus DF, Microthiol Dispers</i>	F Mi	Low		Moderate	High	Low	It may be persistent in soil. It is highly toxic to aquatic systems but tends to have a low toxicity to most other species. It has a low mammalian toxicity if ingested and may be a respiratory and skin irritant. ¹
Tea tree oil <i>PurOleo</i>	F I	Low			Moderate	Low	
Trichoderma spp. <i>Bio-Tam, Vintec</i>	F	Low			Moderate	Low	

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TOXICITY / RISK LEVEL: ■ Low ■ Moderate ■ High ■ No Data

ACTIVE INGREDIENT / PRODUCT & TRADE NAMES EXAMPLES	TYPE	BIRD RISK		WIDE-SCALE EFFECTS			NOTES
		Acute Toxicity	Chronic Toxicity	Environ. Fate	Eco-toxicity	Human Health	
CONVENTIONAL PRODUCTION							
1,3-dichloropropene (D-D) <i>Tri-Cal Trilone II, Telone C-15</i>	F I N	High	No Data	High	High	High	It is moderately toxic to mammals, honeybees, earthworms and most aquatic organisms. ¹ Toxic Air Contaminant (TAC), Volatile Organic Compound (VOC) pollution. ³
2,4-D <i>DMA 600, Herboxone, Weed B Gone</i>	H	Moderate	Moderate	High	Moderate	High	It is moderately toxic to mammals and most aquatic species as well as honeybees and earthworms. ¹ It severely impacted broiler chicks' muscle function, kidney health, and liver integrity and had potential neurological effects. ¹²
Abamectin <i>Agr-Mek, Avid</i>	I Mi	High	No Data	Moderate	High	High	It caused reduced locomotion, increased grooming, and altered feeding patterns of birds. Possible neurological impacts were indicated by behavioral alterations. ¹³ VOC pollution. ³
Acetamiprid <i>Assail, Afflict</i>	I	High	High	Moderate	High	Moderate	Highly toxic to birds and earthworms. Moderately toxic to most aquatic organisms. ¹
Azoxystrobin <i>A-Zox, Quadris</i>	An F	Low	Low	High	Moderate	High	Moderately toxic to birds, most aquatic life, honeybees and earthworms. ¹ PGC pollution. ³
Bensulide <i>Betasan 7G, Prefar 4-E</i>	H	Moderate	No Data	High	High	High	Moderately toxic to birds, fish, aquatic plants and honeybees. ¹
Beta-cyfluthrin <i>Baythroid, Tirade Ultra, Temprid</i>	I	Moderate	High	High	High	High	Highly toxic to fish, aquatic invertebrates and plants, and honeybees but slightly less toxic to birds, algae and earthworms. ¹ Canaries showed high acute toxicity whereas shiny cowbirds had low risk. ¹⁴
Bifenazate <i>Acramite, Floramite SC</i>	I Mi	Moderate	High	Moderate	High	High	It is highly toxic to mammals and a recognised skin, eye and respiratory system irritant. It is moderately toxic to most aquatic organisms, honeybees and earthworms. ¹
Bifenthrin <i>Brigade, Reveal</i>	I	Moderate	High	High	High	High	Concerns about bioaccumulation, oral toxicity to mammals and toxicity to birds, aquatic organisms, honeybees and earthworms. ¹ TAC pollution. ³
Boscalid <i>Emerald, Endura, Pristine</i>	F	Low	Moderate	High	Moderate	High	It can be very persistent in both soil and aquatic systems. Some risk of leaching to groundwater. It is moderately toxic to most fauna and flora although risk is low for honeybees. It has a low oral mammalian toxicity. ¹
Brodifacoum <i>Final All-Weather Blox, Talon WeatherBlox XT</i>	Ro (SGAR)	High	No Data	High	High	High	It is moderately persistent in both soil and aquatic systems. Its toxicity to biodiversity is high to moderate. It is highly toxic to mammals and has a high potential to bioaccumulate. ¹ Owls died of hemorrhaging after feeding on rats killed with it. ¹⁵

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ACTIVE INGREDIENT / PRODUCT & TRADE NAMES EXAMPLES	TYPE	BIRD RISK		WIDE-SCALE EFFECTS			NOTES
		Acute Toxicity	Chronic Toxicity	Environ. Fate	Eco-toxicity	Human Health	
CONVENTIONAL PRODUCTION							
Bromadiolone <i>Brigand Wax Block, SureKill</i>	Ro (SGAR)	Yellow	Grey	Yellow	Red	Red	It may be moderately persistent in both soil and water systems. Moderate to high toxicity to most fauna. May be a reproduction/developmental toxin. ¹ Owls died of hemorrhaging after feeding on rats killed with it. ¹⁵
Bromethalin <i>Agrisel, Assault All Weather Bait, Gladiator</i>	Ro (non-a)	Red	Grey	Red	Red	Red	It may be persistent in soil systems. It is highly toxic to most fauna although data is a little scant. It is also highly toxic to mammals via the oral route. ¹ It bioaccumulates in birds of prey. ¹⁶
Buprofezin <i>Applaud</i>	I	Green	Grey	Yellow	Yellow	Yellow	Moderately toxic to most fauna and flora, the main exception being honeybees for which it has a low toxicity. It also has a low oral toxicity for mammals. ¹
Captan <i>Agrox, Captol, Merpan</i>	F	Green	Yellow	Yellow	Yellow	Red	It has a low mammalian toxicity. Low to moderate ecotoxicity for most aquatic and terrestrial species. ¹
Carfentrazone-ethyl <i>Quinark, Shark</i>	H	Green	Yellow	Yellow	Yellow	Yellow	It has a low mammalian toxicity and no significant negative health effects have been identified. It is moderately toxicity to most species. ¹
Chlorantraniliprole <i>Coragen, Diamide</i>	I	Green	Yellow	Red	Red	Yellow	Highly toxic to aquatic invertebrates, moderately toxic to birds and aquatic plants, and has a low toxicity to bees and earthworms. Chlorantraniliprole has a low oral mammalian toxicity. ¹ PGC pollution. ³ Toxic to butterflies and moths. ³ Monarch butterfly eggs and caterpillars were killed by very low doses and when treated as pupae, the butterflies did not emerge. ²⁷
Chloropicrin <i>Chloropicrin 100, Pic-Chlor 60</i>	F Fm H I N	Red	Yellow	Red	Red	Red	It has a moderate to high toxicity to most biodiversity. The main exception is that it is not considered to be a bee toxin. ¹ TAC, VOC and PGC pollution. ³
Chlorothalonil <i>Orondis Opti, Pegasus DFX Fingicide</i>	F	Green	Yellow	Yellow	Red	Red	Some concern regarding its bioaccumulation potential. It is moderately toxic to birds, honeybees and earthworms but considered to be more toxic to aquatic organisms. ¹ PGC pollution. ³
Cholecalciferol <i>Agri3, Calcitox, Quintox, Terad</i>	Ro (non-a)	Green	Grey	Yellow	Yellow	Red	Tends not to be highly toxic to wildlife with the exception of rodents at specific doses. It may cause adverse developmental/reproduction effects in humans. ¹
Clethodim <i>Agri-Star, Select Max</i>	H	Yellow	Yellow	Red	Yellow	Red	Moderately toxic to birds, fish, aquatic plants, honeybees and earthworms but is less toxic to aquatic invertebrates and algae. It is moderately toxic to mammals. ¹

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TOXICITY / RISK LEVEL: ■ Low ■ Moderate ■ High ■ No Data

ACTIVE INGREDIENT / PRODUCT & TRADE NAMES EXAMPLES	TYPE	BIRD RISK		WIDE-SCALE EFFECTS			NOTES
		Acute Toxicity	Chronic Toxicity	Environ. Fate	Eco-toxicity	Human Health	
CONVENTIONAL PRODUCTION							
Clomazone <i>Caravel 5G, Willowood Clomazone 3ME</i>	H	Low	Moderate	High	Moderate	High	Moderately toxic to most fauna and flora. It is moderately toxic to mammals and is considered to be a reproduction/developmental toxin. ¹
Clothianidin <i>Aloft, Arena</i>	I	Moderate	Moderate	High	High	High	It is moderately toxic to mammals and highly toxic to honeybees. It has a high potential for leaching to groundwater and is very persistent in soil and water. PGC pollution. ³ Ingesting treated seeds may pose chronic toxic risks to small birds, including endangered species. ²⁷
Cyantraniliprole <i>Exirel, Mainspring, Minecto Pro</i>	I	Low	Moderate	Moderate	High	Low	It has a low mammalian toxicity and a low potential to bioaccumulate. It is highly toxic to honeybees, moderately toxic to earthworms and most aquatic species. ¹
Cyflumetofen <i>Nealta, Sultan</i>	I Mi	Low	No Data	Moderate	High	Moderate	Its toxicity to honeybees is low but has a moderate to high toxicity to most other biodiversity. Its oral mammalian toxicity is low. ¹
Cyprodinil <i>Switch, Vanguard</i>	F	Moderate	Moderate	High	High	Moderate	It is moderately persistent in soil and water systems. It is moderately toxic to mammals and there is some concern that it may bioaccumulate. It is moderately toxic to birds, most aquatic organisms and earthworms. ¹
Difenoconazole <i>Postiva, Regev</i>	F	Low	High	High	High	Moderate	Moderately toxic to birds on average, and moderately toxic to humans, mammals and most aquatic organisms. Persistent in soil and in the aquatic environment. Some concerns for its potential for bioaccumulation. ¹
Difethialone <i>FastDraw Soft Bait, Generation Pellets</i>	Ro (SGAR)	High	No Data	High	High	High	It is highly toxic to birds and aquatic life and has a high potential to bioaccumulate. Highly persistent in soils. It is highly toxic to humans and considered to produce adverse effects on the reproduction system. ¹ Besides immediate mortality, SGAR exposure can cause internal bleeding, reduced reproductive success, and compromised immune function in wildlife. ¹⁷
Diphacinone <i>Diphacine, Rodentex Multi-Feed Bars</i>	Ro (FGAR)	Low	No Data	High	Moderate	High	May be persistent in water systems. It is moderately toxic to fish but less so to birds. This substance has a high mammalian oral toxicity and is an eye irritant. ¹ Owls died of hemorrhaging after feeding on rats killed with it. ¹⁵
Eptc <i>Epitome, Eptam 20-G</i>	H	Moderate	No Data	Moderate	Moderate	High	May be persistent in water. It is moderately toxic to most biodiversity. This substance is also moderately toxic to mammals via the oral route. ¹ PGC pollution. ³

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ACTIVE INGREDIENT / PRODUCT & TRADE NAMES EXAMPLES	TYPE	BIRD RISK		WIDE-SCALE EFFECTS			NOTES
		Acute Toxicity	Chronic Toxicity	Environ. Fate	Eco-toxicity	Human Health	
CONVENTIONAL PRODUCTION							
Esfenvalerate <i>Asana XL, Endure ULV</i>	I	Yellow	Yellow	Yellow	Red	Red	It is considered moderately persistent in soil and is non-mobile. It has a high level of toxicity to mammals, earthworms, honeybees and aquatic life. ¹
Etoxazole <i>Eschaton, Zeal</i>	I	Green	Yellow	Yellow	Red	Yellow	May be persistent in some water systems. It's toxic to fish and aquatic invertebrates. It has a low (to moderate) toxicity to birds, honeybees and earthworms. ¹
Flumioxazin <i>Broadstar, Clipper, Payload</i>	H	Green	Yellow	Yellow	Yellow	Red	It presents low (to moderate) risk to birds. It has a low mammalian toxicity and is highly toxic to algae and aquatic plants, moderately toxic to earthworms, honeybees, fish and aquatic invertebrates. ¹
Fluopyram <i>Luna Sensation, Velum One</i>	F	Green	Red	Red	Red	Yellow	
Flupyradifurone <i>Altus, Sivanto</i>	I	Yellow	Grey	Red	Yellow	Yellow	
Fluxapyroxad <i>Merivon, Posterity XT</i>	F	Green	Yellow	Red	Yellow	Yellow	
Glufosinate-ammonium <i>Finale, Rely 280</i>	H	Green	Yellow	Yellow	Yellow	Red	It has moderate toxicity to birds, mammals, most aquatic organisms, earthworms and honeybees. May be persistent in aquatic systems. ¹
Glyphosate-isopropylamine <i>Glypro, Roundup, Talos Liquid</i>	H	Green	Yellow	Yellow	Yellow	Yellow	
Glyphosate-potassium <i>Glystar K Plus, Roundup PowerMax3</i>	H	Green	Yellow	Yellow	Yellow	Yellow	
Hexythiazox <i>Hexamite, Oneger, Ruger</i>	I Mi	Green	Grey	Yellow	Red	Yellow	
Imidacloprid <i>Admire, Guacho, Merit 2F</i>	I	Red	Red	Red	Red	Red	Highly toxic to birds and honeybees. Moderately toxic to mammals and earthworms. High soil mobility and leachability. ¹ In sub-lethal doses, causes genotoxicity, cytotoxicity, immune suppression, reduced growth, and reproductive impairment, even at concentrations below lethal levels. ¹⁸ Earred doves could feasibly be exposed to lethal doses of treated seed in crop fields ¹⁹ PGC pollution. ³

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TOXICITY / RISK LEVEL: Green Low Yellow Moderate Red High Grey No Data

ACTIVE INGREDIENT / PRODUCT & TRADE NAMES EXAMPLES	TYPE	BIRD RISK		WIDE-SCALE EFFECTS			NOTES
		Acute Toxicity	Chronic Toxicity	Environ. Fate	Eco-toxicity	Human Health	
CONVENTIONAL PRODUCTION							
Indaziflam <i>Alion, Esplanade</i>	H	Low	No Data	High	Moderate	High	
Isocycloseram <i>PLINAZOLIN Technology</i>	I	Low	No Data	High	High	Low	It is highly toxic to bees and very persistent in the environment.
Lambda-cyhalothrin <i>Crusader, Ravage II</i>	I	Low	High	Moderate	High	High	It is highly toxic to mammals and is a known irritant. It is also highly toxic to fish, aquatic invertebrates and honeybees. It is moderately toxic to earthworms, and is of bioaccumulation concern. ¹ In pigeons, it causes blood disorders, liver and kidney toxicity, and intestinal degradation. ²⁰
Malathion <i>Fyfanon, Malathion 50% spray</i>	I	Moderate	No Data	Moderate	High	High	It is moderately toxic to birds and earthworms. It is highly toxic to honeybees and aquatic species with the exception of algae. ¹ PGC pollution. ³
Mancozeb <i>Dithane, Manzate, Ridomil</i>	F	Low	Moderate	Moderate	High	High	It has moderate toxicity to birds and earthworms, and is highly toxic to fish and aquatic invertebrates. May be persistent in water under certain conditions. ¹ It causes significant disruptions the regulation of thyroid hormone production and reproduction in munia birds. ²¹
Metam-sodium <i>Vaporooter, L Fume 33</i>	An F H I N	Moderate	No Data	High	Moderate	High	TAC and VOC pollution. ³
Methomyl <i>Lannate, Lanveer</i>	I	High	No Data	High	High	High	Hooded crow and jackdaw carcasses with this pesticide showed death by cholinesterase inhibition. ²² It shows a moderate to high toxicity to most fauna and flora. ¹
Methoxyfenozide <i>Engame, Intrepid</i>	I	Low	Moderate	High	Moderate	Moderate	It has low toxicity to mammals and honeybees, and is more toxic to aquatic species and earthworms. High risk of leaching to groundwater and may be persistent in soil systems. ¹
Methyl bromide (Bromomethane) <i>Brom-O-gas, Tri-Con</i>	F Fm H I Mo N V	High	No Data	High	High	High	It tends to be moderately toxic to most fauna. It may be persistent in soil systems depending on local conditions. ¹ TAC and VOC pollution. ³
Naled <i>Dibrom, Trumpet EC</i>	I	High	No Data	Moderate	High	High	It is highly toxic to birds and aquatic organisms and may pose a risk to honeybees. ¹

PESTICIDE TYPE: (AI) Algicide (F) Fungicide (H) Herbicide (Mi) Miticide (N) Nematicide (Ro) Rodenticide
 (An) Antimicrobial (Fm) Fumigant (I) Insecticide (Mo) Molluscicide (Re) Repellant (V) Vertebrate Control

ACTIVE INGREDIENT / PRODUCT & TRADE NAMES EXAMPLES	TYPE	BIRD RISK		WIDE-SCALE EFFECTS			NOTES
		Acute Toxicity	Chronic Toxicity	Environ. Fate	Eco-toxicity	Human Health	
CONVENTIONAL PRODUCTION							
Oxyfluorfen <i>Goal, Oxy-Star</i>	H	Yellow	Grey	Red	Red	Yellow	
Paraquat dichloride <i>Devour, Gramoxone SL 3.0</i>	H	Red	Grey	Red	Red	Yellow	
Pendimethalin <i>Acumen, Prowl</i>	H	Yellow	Yellow	Red	Red	Red	It has a high potential to bioaccumulate. ¹
Penthiopyrad <i>Aphet, Fontelis</i>	F	Green	Green	Yellow	Yellow	Red	
Permethrin <i>Arctic</i>	I	Green	Grey	Red	Red	Red	It had a negative effect of the breeding success of zebra finches over generations. ²³ It is highly toxic to most aquatic species and honeybees. ¹
Phosphides (Aluminum, Magnesium, Zinc) <i>Eco2Fume, U-PHos Phosphine Fumigant, VaporPh3Os Phosphine Fumigant</i>	I Fm V	Red	Grey	Green	Red	Red	It is toxic to birds, nontarget mammals, and freshwater fish. ²⁴ TACs and VOC pollution. ³
Polybutene <i>Bird-Off Pigeon repellent</i>	Re	Green	Grey	Grey	Green	Green	
Propanil <i>Solanil, Virtue 4SC</i>	H	Yellow	Grey	Yellow	Red	Red	It is moderately toxic to mammals and most other fauna and flora. ¹
Propargite <i>Comite, Omite</i>	I Mi	Green	Grey	Yellow	Red	Red	
Propiconazole <i>Propizol, Tilt</i>	F	Green	Yellow	Yellow	Yellow	Red	
Pyraclostrobin <i>Insignia, Pageant</i>	F	Green	Yellow	Yellow	Red	Red	
Pyraflufen-ethyl <i>Venue, Octane</i>	H	Green	Yellow	Yellow	Red	Red	
Pyriproxyfen <i>Nylar, Provecta</i>	I	Yellow	Grey	Yellow	Red	Yellow	
Rimsulfuron <i>Centrus, Matrix SG, Revolt</i>	H	Green	Yellow	Red	Yellow	Yellow	

PESTICIDE TYPE: (Al) Algicide (F) Fungicide (H) Herbicide (Mi) Miticide (N) Nematicide (Ro) Rodenticide
 (An) Antimicrobial (Fm) Fumigant (I) Insecticide (Mo) Molluscicide (Re) Repellant (V) Vertebrate Control

TOXICITY / RISK LEVEL: Green Low Yellow Moderate Red High Grey No Data

ACTIVE INGREDIENT / PRODUCT & TRADE NAMES EXAMPLES	TYPE	BIRD RISK		WIDE-SCALE EFFECTS			NOTES
		Acute Toxicity	Chronic Toxicity	Environ. Fate	Eco-toxicity	Human Health	
CONVENTIONAL PRODUCTION							
S-Metolachlor (alpha-metolachlor) <i>Helmet, Metalica</i>	H	Low	No Data	Moderate	Moderate	High	
Saflufenacil <i>Sierra, Treevix</i>	H	Low	No Data	Low	Moderate	Moderate	
Sodium chlorate <i>Defol 5</i>	H	Low	No Data	High	Moderate	Low	
Spinetoram <i>Delegate, Radiant</i>	I	Low	No Data	Moderate	High	Moderate	
Spirotetramat <i>Kontos, Movento, Ultor</i>	I	Low	Moderate	Moderate	Moderate	Moderate	
Sulfuryl fluoride <i>Master Fume, Zythor</i>	I V	No Data	No Data	High	Moderate	High	It is moderately toxic to honeybees, aquatic fauna and flora, and humans. It may be a reproduction/fertility toxicant. ¹ TAC pollution. ³
Tebuconazole <i>Adament, Folicur, Mirage</i>	F	Moderate	High	Moderate	High	High	It alters the thyroid function of house sparrow, impacting their plumage quality and potentially their body condition. ²⁵
Thiamethoxam <i>Actara, Cruiser SB, Platinum</i>	I	Moderate	Moderate	High	High	Moderate	Its exposure to eared doves led to a reduction in food consumption and loss of body weight. ¹⁹
Thiobencarb (benthiocarb, bencarb) <i>Abolish, Bolero</i>	H	Low	No Data	Moderate	Moderate	High	
Triclopyr, triethylamine salt <i>Garlon 4, Weed-B-Gone</i>	H	Moderate	Moderate	High	Moderate	High	
Trifloxystrobin <i>Compass, Flint, Luna Sensation</i>	F	Low	Moderate	Moderate	High	High	It is highly toxic to fish and aquatic invertebrates. ¹
Trifluralin <i>Snapshot TG, Treflan</i>	H	Low	Moderate	High	High	High	It has a high potential to bioaccumulate. ¹
Urea sulfate	H	Low	No Data	No Data	Moderate	Moderate	
Ziram <i>Ziram 76DF</i>	F	High	No Data	Moderate	High	High	It is highly toxic to birds, fish and aquatic invertebrates and moderately toxic to mammals, algae, honeybees and earthworms. ¹

PESTICIDE TYPE: (Al) Algicide (F) Fungicide (H) Herbicide (Mi) Miticide (N) Nematicide (Ro) Rodenticide
 (An) Antimicrobial (Fm) Fumigant (I) Insecticide (Mo) Molluscicide (Re) Repellant (V) Vertebrate Control

Bird-Safe Approaches to COVER CROP TERMINATIONS

The ecological benefits of cover crops in agricultural systems have been increasingly recognized, particularly for their role in building healthy soils that lead to resilient crops. When cover crops are growing, they can be beneficial for many birds. However, when the timing of termination coincides with their nesting, some bird species can be harmed.

THE NEEDS AND BENEFITS OF BIRDS

Birds use cover crops for foraging, shelter and nesting. The habitat surrounding the farm helps determine which species are present. Grassland, riparian and wetland birds often move into cover crops. Generalist bird species and those associated with agriculture or other human-dominated landscapes also make use of these areas. The overwhelming majority of species using cover crops provide beneficial pest control services during the nesting season; however a few may become pests later on.¹ Bird species most likely to specifically nest in cover crops are those known to nest in grasses and forbs rather than in shrubs or trees.

Case Study: California's Central Coast

GROWERS' NEEDS AND POSSIBLE TERMINATION CONFLICTS IN DROUGHT YEARS

In California's Central Coast, fall cover crops are typically planted after the main row crop has been harvested, from October to December. Cover crops are terminated in the spring, some later than others, depending on the weather and the planting schedule of the next row crop.

We had heard from a couple farmers that in 2021 and 2022, birds were possibly nesting in their cover crops around the time when they would be terminating them. Rain was below average in those years, with Watsonville, a central point along the coast, receiving only 54% and 84% of normal precipitation, respectively.² The cover crops likely offered more appealing resources than the surrounding natural areas, drawing more birds to nest within them.



Credit: Benketaro



Red-winged Blackbird in mustard cover crop
Credit: Kristin Hugo

BIRD SURVEYS AND TERMINATION CONFLICTS IN A HEAVY RAIN YEAR

To assess the impact of cover crop termination on birds, in the spring of 2023 we surveyed bird presence in 13 fields of seven farms adjacent to natural areas immediately before and during the termination. The cover crop fields contained various mixes of bell beans, vetch, mustard, pea, wheat, oat and phacelia. That year had heavy winter rains totaling 36.2", which was 150% greater than normal. The rains were also late, with 6.6" coming in March.² The heavy and late rains made it difficult to terminate the cover crops earlier than the end of April or beginning of May.

Birds' breeding behavior:

In mornings before the termination, at two fields containing bell beans, peas and vetch, pairs of Song Sparrow, which usually nest in grasses, were seen in these fields, claiming territories. Red-winged Blackbird females, which typically nest in marsh vegetation, shrubs or trees, were seen carrying nesting material into the cover crops, while males were acting highly territorial, defending their space and chasing females. However, none of these birds were observed carrying food, a sign that would indicate they are actively providing for the chicks.

Birds' general use of cover crops:

Many bird species were using the cover crops, and some (those listed in italics below) were seen fleeing the fields as the tractor neared during the cover crop termination. They may have waited to leave until the tractor was dangerously close due to the presence of food or nesting. Ground-nesting species, which

typically nest in grasses and forbs, may have been instinctively preparing to nest there even if no nesting behavior was yet observed.

The birds that were seen include the ground-nesting *Song Sparrow*, *Savannah Sparrow*, *Common Yellowthroat*, *Tricolored Blackbird* (a threatened California species), *Dark-eyed Junco*, *Spotted Towhee*, *Killdeer*, *Mallard* and *Wild Turkey*; the ground/tree-nesting *Mourning Dove*; the shrub/tree-nesting *Brewer's Blackbird* and *American Goldfinch*; the cavity-nesting *Tree Swallow* and *European Starling*; the tree/structure-nesting *House Finch*; the structure-nesting *Barn Swallow*; the marsh/shrub/tree-nesting *Red-winged Blackbird*; and the Golden-crowned Sparrow, which breed outside of California. Afterwards, many of these birds were seen benefiting from the freshly terminated cover crop by foraging for insects. Some were flying off carrying food, likely to feed chicks in nests outside the cover crop.

Nesting cycles and potential farm production conflicts:

Since we observed, in late April and early May, the initial stages of Song Sparrow breeding behaviors and behaviors that may have indicated breeding by, Red-winged Blackbirds and other species, the cover crops would have needed to remain until early June for successful nesting. Species like these take about 34 days to build nests, incubate eggs and fledge chicks.^{3,4} However, delaying cover crop termination could affect several aspects of farm production.

If the crop goes to seed, it may create weed issues for subsequent plantings. Late termination could also delay planting and marketing of the next crop, disrupting the farm's cash flow requirements.

TERMINATION DATES AND LIKELY BIRD NESTING SUCCESS IN A NORMAL RAIN YEAR

In 2024, we tracked the termination dates of seven other cover crop fields, finding that all terminations occurred by April 3, which is almost a month earlier than the previous year. The rains were 97% of normal, totaling 22.8", and only 4.4" came in March.² In this year with normal rainfall, termination likely occurred before much nesting began.

Bird Use of Cover Crops and Hayfields Across the United States

Research from across the United States demonstrates that cover crops and hayfields can provide important habitat for a wide range of bird species, particularly during winter, migration, and breeding seasons. Studies from Tennessee, Illinois, South Dakota, Kansas, Iowa, and New York show that these agricultural habitats can support both common and conservation-priority birds by offering foraging grounds, nesting cover and brood-rearing areas.

The timing and method of cover crop termination or hayfield mowing strongly influence whether these habitats help or harm bird populations. Delayed or adaptive management can support breeding success, while early actions often sharply reduce it.

Tennessee: Benefits, Drawbacks & Early Termination

Similar habitat functions were documented in Tennessee, where legumes, winter wheat, cereal rye and buckwheat (in corn, soybean and cotton systems) supported 70 bird species across winter and migration periods, including focal species like Dickcissel, Field Sparrow, Savannah Sparrow, Red-winged Blackbird, and Eastern Meadowlark.⁵ Cover crops were terminated early before most nesting could begin. Researcher Panos urged the continued **early termination of the cover crop** so that nesting attempts are not made right before terminating. While cover crops will not serve as nesting habitat, terminating them early can redirect nesting activity to areas where success is more probable.

Illinois: Pros, Cons & Termination Timing Effects

In the corn and soybean cropping systems of Illinois, winter and migratory bird assemblages—including Red-winged Blackbird, Common Grackle, American Robin and the Eastern Meadowlark (a species of high conser-



Dickcissels use cover crops for nesting material in Tennessee. Photo credits: Dickcissel from walkingonacountryroad.com (Top) Cover crop mix by Virginia Sykes, University of Tennessee (Bottom)

vation concern)—utilized winter cover crop fields, possibly for foraging and nesting, more than in fields without cover crops. The cover crops were either single species or mixes of cereal rye, crimson clover, radish, winter pea, oats, pennycress, rapeseed and turnip. Cover crop termination was found to reduce nesting success.⁶ Researcher Wilcoxon proposed neutralizing impacts to birds by **delaying cover crop termination until early May**, which would foster nest success in early breeding birds, thereby compensating for negative effects of termination on later breeders.

South Dakota: Advantages, Disadvantages and Alternative Uses

In the northern Great Plains of South Dakota, fall-seeded cover crops (in corn and soybean rotation) such as winter rye provided vital early-season nesting cover for waterfowl – including Blue-winged Teal, Mallard and Northern Pintail – yet termination significantly reduced nest survival below the threshold necessary to support populations of these birds.⁷ Researcher Gallman suggested other ways to incorporate cover crops into production systems that would cause less disturbance during nesting season, such as **grazing or waiting until mid-July or later**, after most chicks have fledged, to hay, cut silage, or harvest the cover crop.

Kansas & Iowa: Minimal Benefits Without Termination Tracking

In Kansas, Ring-necked Pheasant broods benefited from spring cover crops (in wheat and small-grain rotations) when these crops, which offered extra brood-rearing habitat, were located near nesting areas.⁸ In Iowa's corn and soybean rotations, Ring-necked Pheasants rarely used fall-seeded cereal rye and winter wheat cover crops for nesting sites, likely because there was not enough nesting cover for concealment required by this species.⁹ Neither of these studies examined whether terminations were impacting the bird species. Other Kansas studies showed that vegetation height is linked to greater nesting success of grassland birds in grassland habitats.^{10,11}

New York, Illinois and Iowa: Mowed Hayfields Reduce Breeding Success

Hayfields and pastures are often used by grassland birds for breeding. Mowing during the breeding season, just like terminating cover crops, can reduce reproductive success. In New York, Bobolinks had a 29–45% mowing-induced mortality rate in hayfields.¹² In Illinois, only 13% of Ring-necked Pheasant nests hatched after mowing.¹³ In Iowa, mowing reduced grassland birds significantly.¹⁴



Birds shift to foraging on exposed food after cover crop termination. Credit: Jo Ann Baumgartner



Avoiding Ecological Traps

At times, cover crops may be ecological traps – spaces that are perceived as good habitat but do not allow the birds to successfully reproduce and persist.

Drought years on California’s Central Coast may make cover crops more appealing nesting areas, and if they are not terminated early, nesting failures could occur because the cover crop contains active nests that are destroyed during termination. During heavy rain years, especially with late spring precipitation, cover crops may also seem like good nesting areas, but if terminations were to occur very late, for example in mid-May, nests would likely be destroyed. As the climate changes, rain will become more variable, making it hard for farmers to plan ahead.

Our surveys on the Central Coast and the detailed findings of other researchers collectively underscore the role of cover crops as nesting habitat for birds, with timing of termination pivotal for maximizing their safety. Cover crops that support bird conservation and agricultural sustainability can be grown in ways that align termination practices with avian habitat needs.

For Annual Crops, Consider the Following Options:

- Planting as early in the fall as possible will mean the cover crop will be ready for an early termination, if the weather allows.
- No matter when the fall cover crop planting occurs, terminate it as early as possible so there is no cover crop to be used by early nesters.
- Delay the fall-planted cover crop termination so the birds have time to fledge.
- If waiting to terminate the fall cover crop until later in the spring is desired, scouting for nesting birds can help determine if the birds will be impacted.
- Alternatively, plant the cover crop in late winter and plan to terminate after fledging.
- Lightly graze the cover crop, with attention to limiting nest disturbance.

For Perennial Crops:

- Either delay termination of the entire cover crop until after fledging, or terminate alternate rows before nesting begins and the remaining rows once the young birds have fledged.

A vertical photograph on the left side of the page shows a wooden nest box mounted on a metal pole. The nest box is made of light-colored wood and has a flat roof. It is set in a grassy field with a blurred background of trees and a road.

Nest Boxes & Roads: IMPLICATIONS FOR BOX PLACEMENT ON FARMS

By Breanna Martinico and Ryan Bourbour

BACKGROUND

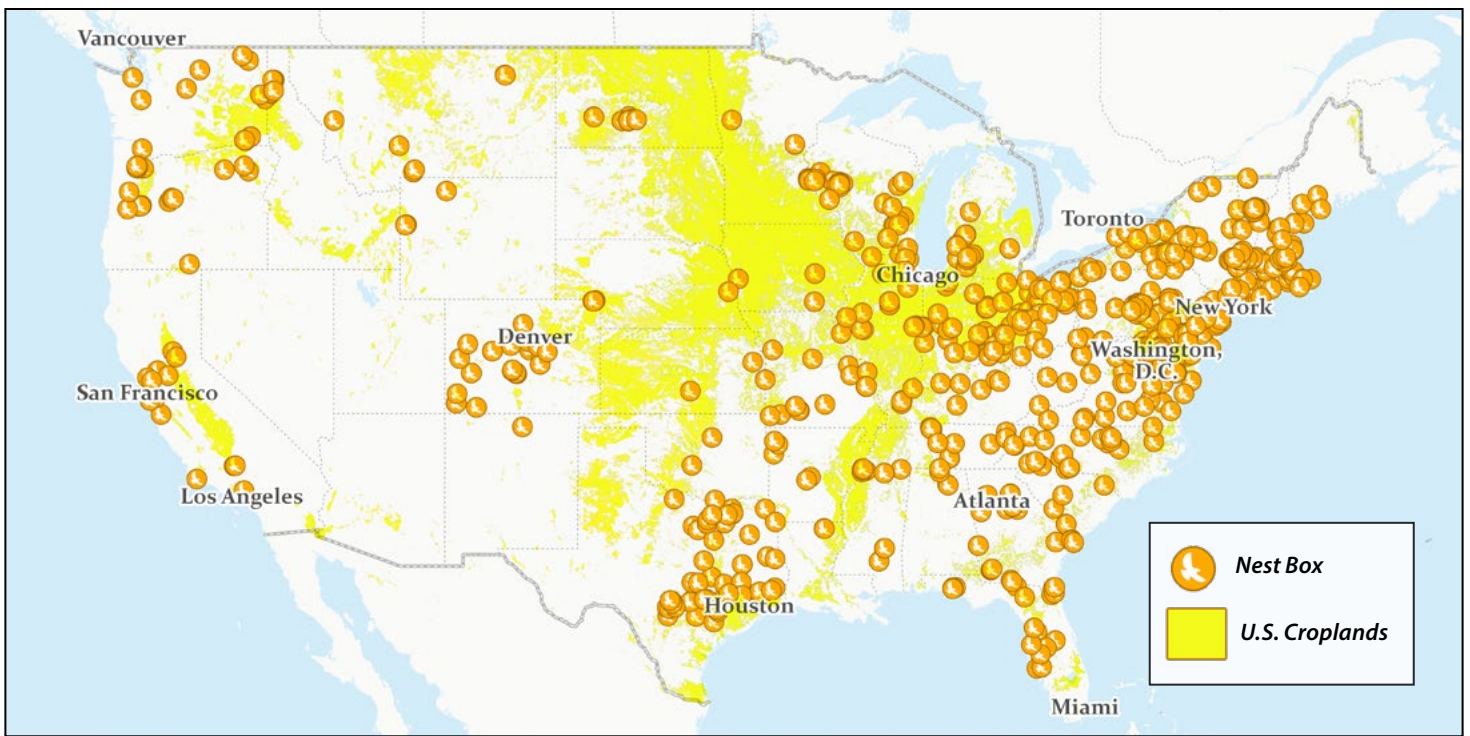
The availability of nest cavities is often a limiting factor for secondary cavity nesting birds, such as Bluebirds and Barn Owls, that are known to be beneficial on farms.^{1,2} Installing nest boxes can increase nesting habitat and can be used to attract beneficial species that provide biological control of agricultural pests. Therefore, understanding how different environmental factors, including roads, influence nest site selection and success can inform optimal nest box placement and management on agricultural landscapes.

The association between breeding birds and roads is complex, but research indicates that the impact of paved roads on breeding birds is generally negative. The creation of roads and their resulting traffic cause habitat fragmentation and degradation, noise and light pollution, and increased predation and vehicle collisions.^{3,4} These stressors compound existing problems and create novel challenges for birds nesting near roads. The direct and indirect effects of roads can lead to elevated physiological stress, reduced breeding output, and even mortality, which may impact species composition and lower bird population densities near roads.^{3,5} Research has shown that nest box occupancy and breeding productivity may increase with increasing distance from roads, suggesting that, when possible, placing nest boxes away from roads may be advantageous.^{6,7} To better understand where to place nest boxes, Wild Farm Alliance teamed up with researchers Bourbour and Martinico at the University of California Agriculture and Natural Resources (UCANR).

METHODS AND RESULTS

Our team investigated whether the amount and type of roads in a bird's home range impacted nest success on agricultural landscapes across the United States. We analyzed nest success in 19 cavity-nesting species commonly found on farms, such as Bluebirds, Swallows, Chickadees, and Kestrels. This dataset was collected by community scientists with the Cornell Lab of Ornithology's NestWatch program and represents 9,806 nesting attempts between the years 2007 and 2020. Nest success is defined as the survival of at least one young from a nest.

Credit: Anne Hamersky



Nest Box Locations: The study analyzed 9,806 nesting attempts of 19 species across the U.S. These nest boxes were monitored from 2007-2020 through the Cornell Lab of Ornithology's NestWatch program.

To collect data on the types and miles of roads birds would encounter near their nest boxes, we examined average home range sizes and mapped the roads around each nest box location. We grouped similar species into estimated home range size categories: small (2 hectare), medium (10 hectare), medium-large (200 hectare), and large (700 hectare) using data collected from published species accounts. We measured the cumulative length of different road types within a species' estimated home range with the help of Geodata Services. We explored the relationship between nest success and the miles of each road type within the home range, controlling for species-specific responses and annual environmental variation.

We found that nest success decreased with increasing miles of major roads (single or multi-lane highways), local roads (rural/city streets), and four-wheel drive trails (off-road vehicle recreational trails found exclusively in very rural areas) within a species' home range. Additionally, major roads had a stronger negative effect on nest success than local roads, suggesting that more traffic, more noise, and higher speeds are more detrimental to nest success. We did not find any significant associations with other road types, such as service roads and farm roads.



Single Home Range Example: Estimated home range buffer (700 hectares) at an American Kestrel nest box. Map shows the land cover types, farmland, forest, and human settlements, in addition to the major and minor roads that an American Kestrel would likely encounter when nesting in this location.



*Research found that major roads near nest boxes negatively impact breeding success.
Credit: Anne Hamersky*

MANAGEMENT CONSIDERATIONS

Nest boxes can easily become ecological traps when placed in non-ideal locations; therefore, it is important to carefully consider external factors when choosing sites for nest box installation. In agricultural areas, nest boxes in locations with a higher density of roads may see lower nest success. **Placing nest boxes further away from roads, and especially avoiding placing them directly along roads, may help boost cavity-nesting species populations and reduce the negative impacts of roads.** If existing nest boxes are near roads, consider moving them to a different location or using predator guards. **Mounting nest boxes individually on poles with baffles and using nest entry extenders deters predators.** The best time to make any of these changes is in the non-breeding season (fall and early winter) so breeding birds are not disturbed. **Installing nest boxes near farm roads is generally acceptable** and can be convenient for access for nest monitoring and maintenance; however, **consider avoiding busier areas on the farm where lights, noises, vehicles, and people are more prevalent.**

OTHER CONSIDERATIONS

Species will respond differently to other environmental factors, such as **the distance to tree cover, nearby water, or preferred habitat**, so consulting other species-specific recommendations will be important for developing new optimal nest box networks on farms. **Cats on or near the farm** make it important to avoid placing boxes within their territories, since chicks' begging calls are easy targets. Other risks include **compost piles that draw rodents and raccoons, bird feeders that attract raptors, riparian corridors that serve as travel routes for predators, and pesticides that cause harm** (see Pesticide section of this document).

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